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SOCIETY OF TELEGRAPH ENGINEERS.

On March 26th, 1873, Prof. AYRTON read a paper entitled "*Some Points in Connection with the Indian Telegraph.*" Prof. AYRTON said that he did not intend his paper to be a complete account of the Indian Telegraph, but he had ventured to select one or two points that he thought might interest those present.

Throughout the greater portion of India there exist two distinct lines of telegraph, one in possession of the Government, the other in the hands of the railway companies. These two sets of lines are almost distinct, being under separate management, and worked by different sets of employés. The rules, however, relating to tariff and to the reception of messages are the same for both systems, and a message may be conveyed partly by Government and partly by the railway lines at a single cost to the sender.

Testing of Lines.—Regular testing of the lines was first introduced into India about the year 1868, and since that time the advantage of executing these tests has become more and more fully appreciated. Every important line is now tested two or three times a week in the following manner: — With a Wheatstone's bridge, or a differential galvanometer, the resistance of the line being taken with positive and negative currents under the three following conditions:—1. When put to earth through the relay at the other end. 2. When put direct to earth (that is relay short circuited). 3. When insulated at the distant end. From the six values thus obtained the following are calculated by equations suited to the form of testing instrument employed:—1. The electromotive force of the natural line current in terms of that of the testing battery, usually about 40 cells. 2. What the apparent wire resistance of the line including the relay at the other end would be were there no natural line current. 3. What the apparent wire resistance of the line excluding the relay at the other end would be on the same supposition. 4. What the apparent insulation resistance would be also on the same supposition. The equations from which these are calculated are determined on the supposition that the difference between the positive and negative readings is due to a natural current uniform throughout the whole line. This is, of course, frequently not the case; as when, for instance, the natural current flows towards each end of the line from about the centre, the connection between the line at that point and the earth being formed by dirt or moisture accumulated on the insulators. In such a case, however, it is extremely difficult to ascertain the distribution of the natural potential at different points of the line; and, in addition, the equations for determining the true means from the positive and negative readings become much more complicated and unsuited for practical use.

The routine for testing is as follows:—The testing station commences by calling the name of the nearest station in circuit on the particular line it wishes to test. The testing station next signals the word "testing." The telegraph master of the station called being at his post, the testing station now signals "Circuit," on which the telegraph master leaves the instrument and line alone until he hears the name of his station called by the testing station. After the word "Circuit" has been signalled, the resistance of the line, including the relay at the other end, is found. Next the testing station signals "Conductor for x minutes," to which the telegraph replies with the temperature (dry and wet bulb) at his office, and at once puts the line direct to earth, short circuiting the relay for the specified time. The testing station next signals "Insulation x minutes," to which the telegraph master replies with the state of the weather, and at once insulates the line for the time specified. By following out this routine rigidly the tests are performed with certainty and dispatch. In testing for faults, when a post has been blown down and all the lines have tumbled into water, so that it is impossible to communicate on any line, then at the commencement of the next hour (Madras time) after the fault has occurred, the office at the end of the interrupted section insulates all lines from the hour to fifteen minutes past the hour, then puts them to earth through the relay for the next fifteen minutes, then puts them direct to earth for the third fifteen minutes, and for the last fifteen minutes of the hour loops the lines in pairs previously settled in printed instructions supplied to each office. This routine is repeated every hour until communication is restored. After the fault has been localised a telegram is sent, if possible, to the office nearest the fault, telling them where to send a man, and what sort of fault he will have to look for. In this way one man going from the nearest office is able to remove the cause of interruption, whereas, before the systematic introduction of testing in India, two men travelled along the line, one from each end of the stations at the end of the interrupted sections, until one or other found the fault.

Prof. AYRTON then proceeded to discuss fully the questions of insulators, signalling instruments, and batteries; the paper being most exhaustive in character, but obviously too lengthy for our columns.

ROYAL SOCIETY.

A paper "*On a New Relation between Heat and Electricity*," was read by FREDERICK GUTHRIE. It is found that the reaction between an electrified body and a neighbouring neutral one, whereby the electricity in the neutral body is inductively decomposed and attraction produced, undergoes a modification when the neutral body is considerably heated.

Under many circumstances it is found that the electrified body is rapidly and completely discharged. The action of discharge is shown to depend mainly upon the following conditions:—(1). The temperature of the discharging body. and its distance from the electrified one. (2). The nature (+ or −) of the latter's electricity.

With regard to (1), it is shown that the discharging power of a hot body diminishes with its distance and increases with its temperature. But, concerning the temperature, it is proved that the discharging power of a hot body does not depend upon the quantity of heat radiated from it to the electrified body, but chiefly upon its quality. Thus a white-hot platinum wire connected with the earth may exercise an indefinitely greater discharging power, at the same distance, than a large mass of iron at 100° C., though the latter may impart more heat to the electrified body.

Neither the mere reception of heat, however intense, by the electrified body, unless the latter have such small capacity as to be itself intensely heated, discharges the electricity if the source of heat be distant, nor is discharge effected when the electrified body and a neighbouring cold one are surrounded by air through which intense heat is passing; but, for the discharge, it is necessary that heat of intensity pass to the electrified body from a neutral body within inductive range.

White and red-hot metallic neutral bodies exercise this discharging power even when isolated from the earth, but always with less facility than when earth-connected.

The hotter the discharging body, whether isolated or earth connected, the more nearly alike do + or − electricities behave in being discharged; but at certain temperatures distinct differences are noticed. The − electricity, in all cases of difference, is discharged with greater facility than the +.

Attempts are made to measure the critical temperatures at which earth-connected hot iron (1) discharges + and − electricity with nearly the same facility, (2) begins, as it cools, to show a preferential power of discharging −, and (3) ceases to discharge −. The temperatures so obtained are measured by the number of heat-units, measured from 0° C. in 1 grm. of iron of the respective temperature, represented by the value of the expression $Fe\Sigma_0^t u$.

It is shown that various flames, both earth-connected and isolated, have an exceedingly great power of discharging both kinds of electricity.

The effects in regard to discharge are shown to be similar when platinum wire, rendered hot by a galvanic current, is used, and also when the condensed electricity of a Leyden jar is experimented on.

As hot iron shows a preferential power of discharging − over + electricity, so it is found that white-hot, but isolated, iron refuses to be charged either with + or − electricity. As the iron cools, it acquires first the power of receiving −, and afterwards of receiving +. Further, while white-hot iron in contact with an electrified body prevents that body from retaining a charge of either kind of electricity, as it cools it permits a + charge to be received, and subsequently a − one.

A suggestion is made as to the existence of an electrical coercitive force, the presence of which, together with its diminution by heat, would explain much of what has been described.

SOCIETY OF ARTS.

A paper was read by W. Lloyd Wise, A.I.C.E., M.I.M.E., "*On Gas-lighting by Electricity, and Means for Lighting and Extinguishing Street and other Lamps*," who said:—Some curiosity having been excited by various newspaper paragraphs which recently appeared relative to experiments made first in Germany, and subsequently at Preston, in lighting gas by electricity, on the plan invented by Prof. Klinkerfues, director of the Royal Observatory at Gottingen, it was suggested that a paper might lead to useful discussion at a meeting of this Society.

The advantages to be derived from a practicable system of igniting gas, without the use of an exposed flame for the purpose, will be fully appreciated by those acquainted with the difficulties and dangers attending the ordinary methods of lighting gas, and the frequent accidents arising from the careless use of matches and negligent ignitions, not only in private houses, but also in warehouses, magazines, cotton mills, and work-rooms, especially where the manufacture of inflammable materials is carried on. There is, also, considerable inconvenience and waste in connection with the lighting-up of turret clocks, and the ignition of gas in other places difficult of access, where, in some cases, to save the great trouble of lighting and extinguishing, the gas is kept constantly burning, instead of being extinguished during the daytime.

Then, as to street lamps, several important points claim attention.

The old-fashioned system of carrying a ladder, with a lighted fuse, from lamp to lamp, though still used in many towns, has, nevertheless, been somewhat improved upon by the introduction of the lighting staff; notwithstanding the use of which, however, our present mode of street lamp-lighting is a tedious, wasteful, and expensive process.

Not only does it involve the employment in every considerable town of a large staff of lamplighters, but in order that all the lamps may be lighted by dusk, the lighting operation has to be commenced some time before any lights are really wanted, so that gas is consumed to no purpose. The same rule applies conversely to the extinguishing of the lights; hence the loss of gas night and morning from these causes alone in a large town must amount to something considerable in the course of a year.

In Bristol, where they have about 3600 lamps, one man is told off for every hundred, and, in order to get the lamps lighted by a given time, the lighters must commence their duties an hour previously. Again, the hours during which gaslight is required at any given time of the year vary considerably, according to the state of the weather, and under present arrangements, in order to be on the safe side, the lights have often to be kept up when they might be dispensed with.

Many plans have been from time to time proposed for igniting gas by electricity, but it would be impracticable to describe them within the limits of a paper.

Mr. Simon Petit proposed lighting several gas-jets simultaneously, or in very rapid succession, by providing each burner with a valve or cock, to be opened and closed by means of an electro current, acting directly upon it by means of an electro-magnet or coil, or indirectly by a releasing detent, an electric spark being passed through the issuing gas at the moment of opening the valve or immediately afterwards.

At about the same time Mr. Isham Baggs proposed certain arrangements for instantaneously igniting gas by the use of frictional or high-tension electricity, as also means for turning on and off the gas when required.

The burner of each lamp was to be provided with a strip of glass, or other non-conducting material, placed horizontally, having a couple of wires passed through it, one at each side of the burner, the end of the two wires being brought close to each other at a short distance above the aperture of the burner. To the lower ends of these wires others were to be attached, suitably insulated from the metallic portion of the lamp, and joined to wires connecting it to the other lamps in a given circuit. Several plans were suggested for turning the gas on and off, one being to provide several burners with a common tap, to be turned on and off by air pressure and vacuum in a small cylinder containing a piston connected to the lever of the gas tap.

For effecting the ignition Mr. Baggs preferred to use an ordinary plate electrical machine and a Leyden jar, or combination of jars, for sending the requisite currents of electricity through the wires of each circuit.

Another plan, proposed by Mr. Denny Lane, was the use of a portable battery, to be carried from lamp to lamp, a piece, or pieces, of platinum wire being suitably placed in proximity to the orifice of each burner.

More recently Mr. Robert Cornelius brought out a plan for igniting gas by an electric spark, generated by frictional electricity, at the point of a wire bent over the top of a gas-burner. A chain attached to this wire was carried to some accessible point, and upon being touched by a portable electric apparatus, or acted upon by a stationary battery fixed in any convenient position, a current of electricity was conveyed to the pointed wire over the burner, and the gas issuing from it thereby ignited. He proposed several kinds of small stationary frictional batteries suited to the purpose named, and also a small portable battery, in the form of a tube, with a metal rod, coated with vulcanite, working loose in the inside. The tube was to

be lined with lamb's-skin, or other suitable material adapted for the purposes of frictional electricity, the depression or elevation of one end of the tube causing the metal rod to slide downwards by its own gravity, so as to excite sufficient electricity for lighting the gas issuing from the burner.

Mr. Barbarin subsequently proposed two plans, one involving the combined use of electricity and clockwork, a very complex arrangement; the other dispensing with the clockwork and electric currents, and employing a quicksilver closing, and hydrogen gas, in conjunction with spongy platinum, for igniting the gas.

I am indebted to Mr. Ladd for the following information as to the lighting arrangements at the Royal Albert Hall, South Kensington:—

The lights are arranged in thirty clusters, of five stars each, each star containing twenty-one jets or burners. A bichromate battery is made to work an inductorium, or induction coil, connected to which is a semicircular insulated arrangement. Attached to this are thirty wires, which lead off, one to each of the thirty clusters.

The burners are arranged in sets of three, somewhat like a three-pronged fork, and the ends of a couple of platinum wires, connected with the battery, are fixed within a short distance of each other, near the orifice of the centre burner of one set in each star, there being a special conducting wire from the battery to one of the stars in each cluster, or thirty wires in all. When the galvanic circuit is closed, by lowering the plates of the battery into the acid, a spark is caused to pass from the point of one platinum wire to the other, and thereby ignites the gas issuing from the burner. Since that burner is within lighting range of its neighbours at each side, they in turn with those next to them, and so on, the ignition of the gas proceeds from one to the other all round the star. The platinum wires are held by iron wires, attached by a small block of steatite to the stem of the burner, and are placed slightly below the horizontal line of the burner orifice, so that when the gas is alight the upward draught draws the flame away, and so prevents deposit of carbon upon them. The gas is turned on and off by stopcocks in the mains in the ordinary way.

Prof. Klinkerfues's arrangements are based upon the use of compact platinum, in connection with a galvanic battery, without the intervention of any coil, by the movement of the plates or of the electromotive liquid by mechanical means, or by gas pressure completing the galvanic circuit, the gas being at the same time brought into contact with the heated platinum wire, and thereby ignited. His experiments demonstrated that for this purpose less than a red heat was required, as a platinum wire inserted between the poles of a very small pair of zinc and graphite, without showing the slightest emission of light in a dark room, ignited a jet of gas almost instantaneously.

For opening and closing the gas passage leading to the burner, and lighting or extinguishing the gas as required, by simply altering the pressure in the main, he combines a bell-shaped compartment with the gas-pipe and the vessel containing the electromotive liquid in such a way that when the gas is at its lowest pressure the liquid seals the gas-pipe. By increasing the gas pressure the passage to the burner is opened, and by a still further temporary augmentation of the gas pressure, the galvanic circuit is completed, so that the issuing gas, impinging upon the platinum wire between the poles of the battery, is ignited.

In its most simple form, his apparatus constitutes a hand-igniter, to be used in lieu of matches, spills, or tapers, for lighting gas at any burner. It consists of a thin, hollow glass vessel, several inches high, closed at the bottom, and provided with a cover which screws into a mounting attached to the neck of the vessel, so as to hermetically close it. The cover has fixed to it, and carries beneath it, the galvanic pair, consisting of a perforated tubular piece of zinc, and a cylindrical piece of graphite or carbon. Above the cover are the electrodes, connected by a piece of platinum wire. The electrodes consist of two brass wires, one of them screwed into the metal cover, which is in direct contact with the zinc; the other passes to the carbon through the cover, from which it is insulated.

In order to light gas with this simple apparatus, it is only necessary to incline it sufficiently to bring the liquid into contact with the zinc and carbon pair, and at the same time to hold the platinum wire in contact with the jet of gas issuing from the burner. When the apparatus is placed in an upright position, the zinc and carbon do not touch the liquid, consequently no galvanic action takes place, and no material is consumed.

The street-lamp arrangement is designed to simultaneously light or extinguish a number of lamps from a single station. It being desirable that the gas supply should be shut off at points in close proximity to the burners, it is necessary that some means should be provided for opening and shutting off the supply from a distance. As we have already seen, it has been proposed to do this in various ways, one plan being to use stopcocks in conjunction with electro-magnets worked by galvanic action from a common station. But Prof. Klinkerfues, considering that galvanic batteries intended for the production of caloric should be of weak resistance, and therefore incompatible with great lengths of conducting wires and long duration of galvanic action, without frequent renovation of the liquid, decided to furnish each lamp-post with its own galvanic apparatus, and to make the galvanic pair touch the liquid only during the short time necessary for lighting up. In his apparatus for this purpose the vessel containing the liquid is provided with an internal tube leading to the burner, and having an enlargement at its lower part, as already mentioned. This tube is attached at its upper end to the cover. The gas-pipe enters the vessel at its lower part, and terminates within the tube. The carbon rests upon the enlargement of the tube leading to the burner; and the zinc, in the form of a ring, which is insulated from the tube, is attached to a screwed wire or rod, surrounded at its lower end by insulating material, and passing up through a suitable insulator in the cover to a connecting bar, upon which rests a nut, whereby the zinc is held and adjusted.

One of the electrodes is attached directly to the connecting bar, and the other is insulated from the bar and attached to the cover. The upper end of the gas-pipe, situated within the tube leading to the burner, is perforated, and a cap, adjustable by a screw, which screws into the pipe, fits easily over it, the lower end of the cap passing down below the level at which the liquid stands when the gas is at its lowest pressure. An annular space is thus left between the cap and the gas-pipe, and the interior of the latter communicates by the apertures at its upper end with the annular space.

The action of the apparatus is as follows:—When the gas is at its lowest pressure, and the surface of the liquid in the annular space between the gas-pipe and its cap is at or about its highest level, the liquid seals the lower part of that annular space, thereby preventing the passage of gas into the tube, and thence to the burner. By slightly increasing the pressure of the gas, it will force the liquid down in the annular space, thereby raising the level in the main vessel until the gas is permitted to pass by the tube to the burner, and then, by a still further augmentation of the gas pressure for a few seconds, the liquid is temporarily forced up in the vessel into contact with the zinc, thereby completing the galvanic circle, and igniting the gas

issuing from the burner as it comes in contact with the heated platinum wire. After this is effected, a slight remission of the gas pressure causes the level of the liquid in the vessel to fall below the zinc, thereby breaking the galvanic circuit in order to avoid unnecessary exposure, but without shutting off the supply of gas to the burner. The extinction of the light is effected by reducing the pressure, so that the level of the liquid rises up within the annular space between the pipe and its cap, and thereby shuts off the communication to the burner. The apparatus is accommodated to variations of pressure at different altitudes, by adjusting the position of its cap and the extent to which it dips in the liquid by means of the screw.

The practicability of this apparatus was first publicly demonstrated by a three months' test in Gottingen, where it was applied to forty-street-lamps in the principal thoroughfares; and the Gas Commission, of which the mayor was a member, certified on the 21st of March last that the apparatus had worked continuously to their satisfaction.

Mr. Ladd said he had always adopted the induction spark. The apparatus at the Royal Albert Hall was of far greater power than was wanted. It was originally intended to light five jets at a time. The same principle had been carried out in the east laboratories of the Royal Arsenal, where two platinum wires were set in a small block of steatite, and these were fixed immediately below the burner. The wires were connected with a coil, and as the spark passed, the gas was turned on and ignited. After a great deal of practice he found there was really little or nothing left to be desired to perfect the arrangement. In the east laboratory there are twenty-four houses to be lit, all protected by glass underneath the burners; a man goes down with a little battery and coil, and puts it against the two wires outside the door, turns on the gas, and so lights it, and no possible danger can ensue. A very pretty arrangement came over from America a few years ago, which he believed was presented to Mr. Faraday. A little ebonite plug, lined with silk, fitted in a cup, and the wires were brought up to the burner. All you had to do was to lift the plug out of the cup, and the gas lit.

THE METEOROLOGICAL SOCIETY.

The ordinary meeting of this society was held on Wednesday, March 19, 1873, the President, Dr. J. W. Tripe, in the chair.

A paper entitled "*On some Results of Meteorological Telegraphy*," by R. H. Scott, M.A., F.R.S., Director of the Meteorological Office, was read by the author, who commenced by remarking that the numerical and other data published in the daily weather reports were generally considered to give such an idea of the weather at the stations selected as the meteorologist would obtain by personal observation, and that therefore they could be used for various purposes of inquiry as well as for the communication of signals to our seamen and fishermen. This, Mr. Scott said, was a mistake, and proceeded to enumerate the difficulties which the office had to contend with in obtaining the information by telegraph. In many cases the positions of the meteorological instruments were unsatisfactory. The interruption to telegraphic communication on Sundays was a great drawback, *in addition to the numerous telegraphic errors, no less than 299 having occurred in six months;* the need of more frequent telegrams than one, or in a few cases two, daily was mentioned, and the author, contrasting the single service of the United States, which published three weather maps daily, with our own system, remarked that these difficulties could not be overcome until all the observers were in the pay and under the control of the office. Mr. Scott, in alluding to the exposed character of the British Isles, referred to the proposition that had been made for mooring a signalling ship some hundred miles from the coast westward, and also to that of obtaining information by telegraph from the Azores. So far as the latter proposition was concerned there was really no connection between the movements of the barometer at the Azores and Valentia; the systems were perfectly distinct, and we could expect no warnings from the Azores, as the storms which passed over those islands travelled from north-west to south-east, towards the African Continent. In connection with the warnings issued from the office, "they should," said Mr. Scott, "be short and explicit." He had reason to believe that both the drum and cone had been misunderstood, the drum indicating "strong winds," the cone "gales," and the two combined "gales of dangerous force." It was a question whether the drum should only be used to warn fishing-boats, and the cone sea-going ships. It was the opinion of the late Commodore Maury, that signals should only be hoisted when the coming gale was expected to be of a hurricane force; but it is manifest that in these islands it is difficult to determine beforehand whether the wind in an expected storm will attain the force of a hurricane or not. There exists a growing desire to return to the late Admiral Fitzroy's system, which now only remains in force in Portugal, but it is uncertain whether it will be re-adopted. Two plans have been suggested for giving warnings without employing the drum and cone, viz., by the use of the semaphore and of an instrument called the aëroklinoscope, which Mr. Scott described. The paper concluded with some remarks on the comparison of information obtained by telegraph with the facts observed, in which it was stated that more than one station is necessary on any given coast line, and instanced Scilly, Plymouth, and Portsmouth, on the south-coast of England, as furnishing much more reliable information than could be obtained from one of those stations alone. In consequence of the absence of observing and telegraph stations on the west coasts of Ireland and Scotland, these extensive coast-lines are excluded from the benefit of the system.

INSTITUTION OF ENGINEERS AND SHIP-BUILDERS.

A meeting of the Institution of Engineers and Shipbuilders was held (March 18, 1873) in the Natural Philosophy Class Room of the Glasgow University—Mr. Robert Duncan, President in the chair.

Professor Sir Wm. Thomson explained and illustrated the working of submarine cables by signals through a model submarine cable, exhibited by a mirror galvanometer and by "Siphon Recorder." He commenced by referring to Faraday's explanation of what is called the "inductive retardation of signals in a submarine cable." The wire constitutes, as it were, the inner coating of a Leyden jar, the gutta-percha or india-rubber takes the place of the glass, and the water touching the outside of this represents the outside coating of the jar. Faraday showed that if several thousand Leyden jars were distributed along an aërial line of telegraph, each with its inside coating connected with the telegraph wire, and outside coating with the earth, the signals through the line would exhibit exactly the same inductive retardation as those sent through the actual submarine line. Mr. Cromwell Varley had devised a beautiful practical method for realising this suggestion. He first made condensers of sufficient capacity to represent the submarine line. A dozen or so of these condensers distributed along the line of resistance coils, according to Faraday's rule, gave the electrostatic capacity to which the inductive retardation is due. In these condensers, in a moderate compass, a large number of sheets of tinfoil packed closely together with insulating

material between them in order, gave, by the great amount of surface thus got, and the thinness of the coating, the enormous amount of electrostatic capacity (*quasi* Leyden jar capacity) which is necessary to represent a few miles of submarine cable. By these condensers, applied properly to resistance coils, Mr. Varley constructs what he calls an artificial line, and such a line was supplied by him to Sir W. Thomson with capacity equal to the French cable and resistance equal to four times that of the conductor of that cable—that is to say, equal to about 10,000 miles of such a conductor as that of the French cable. The degree of inductive embarrassment of the French cable on account of its great length—about 2500 miles—is greater than that of any other cable except those between Suez and Aden, and between Aden and Bombay, which in that respect are about equal to the French cable; because, although of shorter length, their conductors are of less weight per mile. Thus the appliances exhibited may be represented as a model of any of these three cables. The signals through this model cable were shown by means of a mirror galvanometer with lime light, throwing an image on a scale at a distance of nine feet from the mirror. After making simple right and left signals, he showed that by pressing down one key the spot of light was sent slowly to the right or left, reaching an extreme deflection after several seconds of time, and remaining there as long as the key was held down. He then showed a repeated succession of signals to the right and left, groups of these constituting letters. He then explained the essence of submarine telegraphy in making another signal without waiting for the end of that preceding, and the interpreting by eye and memory, when reading from the spot of light, what the complete deflections would have been if they had been made separately. The same things were shown on the "Siphon Recorder," an apparatus by which a siphon of very small bore is made to record the signals in ordinary ink on ribbons of paper. He afterwards showed that in sending direct from the battery, and receiving through a condenser, there was a great quickening of the signals, and that interposing a condenser at the sending end diminished the amount of deflection, but quickened it very considerably. The application of this quickening method on the "Siphon Recorder" was also shown.

Sir William Thomson afterwards showed an apparatus illustrative of "friction dynamometers." He thought the method of measuring force by means of friction had not received so much attention as it should have got. A small working model of Stirling's air-engine had passed round its fly-wheel a piece of string carrying at one end a weight of 100 grains and at the other 700 grains, and he showed how, by the equalising of the weights through the friction of the string, the amount of work done by the engine could be calculated. An apparatus consisting of a fly-wheel, over which a rope was passed, having at one end a weight of 28 lbs. and at the other a spring, showed by the contraction of the spring the work done by two men in turning the wheel. The simplicity of the principle thus illustrated was pointed out, and its application to sounding the sea at great depths shown. An apparatus for the purpose of taking soundings was placed at one of the windows, and the working of it by means of the frictional dynamometer exhibited. One great advantage is the simplicity of the apparatus, and the ease and certainty with which it can be ascertained when the line has reached the bottom. This is effected by keeping such a strain on the dynamometer (which can easily be calculated) as will prevent more line running out when the gravity of the leaden plummet at the end is taken off the line by its reaching the bottom. Professor Thomson expressed his preference for wire as a sounding apparatus, and explained a method communicated to him by Mr. James Young of preventing it from rusting by saturating the water clinging to it with lime.

At the conclusion, the chairman proposed a hearty vote of thanks to Sir William Thomson, which was cordially awarded.

New Inventions.

CHAPIN'S ELECTRO-MAGNETIC CONTINUOUS RAILWAY BREAK.

The apparatus consists mainly of a battery and keyboard, conductors and magnetic clutch, and the mechanical arrangement of gear for applying the blocks to the wheels. The battery used is that known as Highton's, consisting of 16 cells, and is placed in each guard's van. Conductors pass through the train, the couplings of which are very ingenious and simple, being so arranged, that should the train part, the circuit would be instantly reformed, and the break as perfect as before, each part of the train having its own break apparatus complete. A magnetic clutch is placed under each carriage, which is constructed as follows:—A horizontal shaft having a friction roller loose on it in contact with one of the carriage axles, is supported at one end by a fixed bracket, and at the other by a sling link; adjoining this link and on the shaft is a fusee, to which is attached a chain on the shaft, and having a wrought-iron friction plate in contact with an armature revolving with the friction-roller, is provided with a cast-iron disc, provided with two electro-magnets; play is allowed to the armature plate, so that it can approach to or recede from the friction plate. The main wires or conductors are connected to the magnets by means of two saddle pieces, spanning corresponding grooves in brass rings, fixed on a wooden collar pinned to the axle; this of course allows the shaft to revolve without disturbing the wires. Along the shaft, protected by coils of hemp, pass the two wires from the magnets to the saddle pieces, so that the current of electricity passes from the battery, down one saddle piece, through the magnets, and up the other saddle piece, then to the next clutch, and so on till the circuit is complete. Under each carriage and fixed to suitable framing are two levers, one horizontal, having its fulcrum in the centre of the carriage framing, and the other, vertical, to one end of the latter is attached a chain, connected to the fusee on the clutch shaft, while another chain is connected to it (the vertical lever) nearer its fulcrum, the other end of which then is attached to the end of the horizontal lever, to which are also connected tension rods extending to the break block cross bars. The blocks are of wood, hung in the usual manner, The application of the break is effected by simply moving the key in the guard's van. The shaft thus winds up the chain to remove the breaks; the current is reversed, and the armature is released, and the blocks are drawn off by means of springs fastened to the head-stocks of the carriage. A local battery is fixed in each carriage, the conductors of which have in their circuit the magnetic clutch and a key-board fixed on the roof of each carriage. The circuit is kept open by means of a cord passing through the keys to the vans at either end of the train, where its extremity is loaded with a weight to keep it tight. On the train parting the cord is broken, and the keys by means of small springs instantly complete their circuits and apply the breaks.

RAILWAY SIGNALLING.

One of the most important applications of electricity is to the various devices for the prevention of accident

on our railways. Although many mechanical apparatus have been invented, the peculiar nature of the electric current would appear to warrant the assumption that mechanical contrivances can be of value only as auxiliaries to the electrician. We have been favoured with a description of the Electric Semaphore Block Signalling Instrument, which has been devised by Messrs. F. Russell for adaptation to the existing block system. It consists of a case, on the top of which is mounted a miniature post, having one, two, or more semaphore arms, discs, or cross-arms, as occasion may require. The arms or discs are painted similarly to the out-door signals. On the top of the case, in front of the column, is a switch or spring lever, working in a quadrant, which serves to throw the battery current in connection with the line wire. The spring on this lever is sufficiently strong to prevent any accidental movement. In the front of the instrument is a "tapper" or ringing key for ringing the bell at the distant station—the bell being in the lower part of the case. The case measures 14 in. × 11 in. × 9 in. high, and the column stands 18 in. above the case.

The position of the arms is made to represent the state of the line to which they refer, "Blocked," or "Clear," as the case may be. A signalman who understands the outdoor signals thus necessarily understands the electric signals. Each man sees on his own semaphore the position in which he has placed the arms at the other station. The red arms can only be lowered by the signalman at the station towards which the train is approaching; while the white arm is moved by the switch of its own instrument.

The signals used to indicate "danger" and "all clear," to the signalman are the same as those exhibited to the driver. The normal state of the instrument is with the arms raised to "danger." The arms remain at "all clear" so long as a current is flowing from the battery to the line; but the moment the current is cut off, the arms fly up to "danger," the whole apparatus being in equilibrium. It is impossible to lower the arms except by the action of the electric current, and to maintain that signal except by the persistent effect of the battery at the other station. The signal therefore, it will be seen, is solely under the control of the signalman towards whom the train is approaching. The signal cannot be reversed either by lightning or any other atmospheric disturbance. Only one battery is required to work the arms and bell signals for a pair of roads. There are no reversing currents employed, and the battery is being used only while the position of the arms is at "all clear." Any rupture of the line wire immediately throws the arms up to "danger." The semaphores may be constructed so as to be placed perfectly at the command of the plate-layers on the line. No battery would be required, but only a few feet of wire, and after the line was again ready for traffic, the red arms could be lowered again.

Another method of securing safety to the railway passenger has been provided by the electric signals and train registering apparatus of Mr. W. R. Sykes and Mr. F. R. Francis. By this arrangement it is impossible for two trains ever to be between two stations, as the signals are worked by each train in advance. In this system suitable springs are fixed to the rails at certain points, of sufficient strength to resist the weight of a man, but not sufficient to oppose the weight of a carriage or other conveyance, and are permanently secured at one end, the other end being fitted to work in a socket, perfectly insulated from the rails, which, on a carriage or other conveyance passing over the spring, a contact is made, causing an electric current to pass to electro-magnets in the signal-lamps, or in connection with the signal-arms, and by their attractive power a double diaphragm of green and red glasses is made to give a red light, or, in the case of arms, place the signal at "danger." This having been done at two points of the line, on reaching the third point the signal here is placed at "danger," whilst the two former are put to "line clear." For example, a train leaving station A with the clear signal, passes over No. 1 spring in connection with the same, and instantly puts it at danger; on reaching No. 2 spring it acts in the same manner, putting the signal there also at danger; it then proceeds to station B, and on passing out of this station it passes over No. 3 spring in connection with the lamp or signal-arm at that station, placing that at danger, and at the same moment putting the two former signals at line clear, thus enabling another train to leave station A, working its signals as did the first train. On arriving at station B, should the signal there be found at line clear, it is certain that the first train must have passed the third station, and the second train could proceed in safety. By the adoption of this new system, no signalmen are required at any stations other than at termini and junctions.

The use by railway companies of a means of communication between passengers and guards in railway trains has long been compulsory, but no definite plan has been selected. Cord communication has been condemned, and the various systems of electric signals are still open to improvement. One of the most recent electrical apparatus has been lately applied to a Great Eastern railway train running between Victoria Park and Stratford Bridge. The innovation is upon Colonel Binney's system. The conductors consist of a couple of wires carried along the roofs of the carriages. Each guard's van is provided with an electric bell. One terminal of each bell is connected to one pole of each battery, the other terminal being connected to one of the train wires passing along the tops of the carriages. The other train wire is connected to the second pole of the battery, so that no current of electricity can pass until the two train wires are connected together. To effect this a communicator or "push" is placed in each compartment of every carriage, and which is used when passengers require to give an alarm to the guard.

Students' Column.

Application of the Condenser.

The most important applications of the condenser are to submarine cables, whether as regards the testing of their capacity or their working. The tests as to capacity of a cable by means of a condenser are well laid down in the various handbooks of telegraphy, but the public have received very little information as to the use of the condenser in signalling through submarine cables. The best description with which we are acquainted is that found in Pope's "Modern Practice of the Electric Telegraph,"* and we quote this for the benefit of our students, following the principle with which we set out,—that is, to indicate our sources of information.

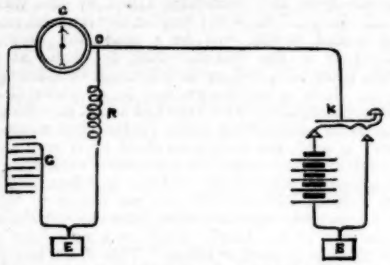
Different parts of the earth and sea are found to be at different electric potentials. One part is electro-positive or electro-negative to another. That is to say, there is the same difference between the two parts of the earth that exists between the two poles of a battery. If, therefore, these two points are joined by a wire, a current will flow through that wire as if from a battery; and this current is termed an earth-current, to distinguish it from the current generated by an ordinary voltaic battery. This difference of potential between two given points, such as Newfoundland and

* Modern Practice of the Electric Telegraph. A Handbook for Electricians and Operators. By Frank L. Pope. Seventh Edition. New York: Van Nostrand.

Valentia, is not constant, but continually varies, causing a corresponding variation in the current it produces. This current and its fluctuations interfere with the signalling current, disturbing the distinctness of the signals.

The manner in which the condenser is made use of in working a cable is as follows:—The apparatus consists of a battery, B, Fig. 13, which is permanently

FIG. 13.



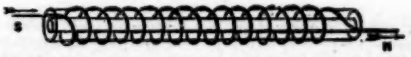
connected with the cable through the back contact of a Morse key, K, and the cable is therefore kept constantly charged from this battery. When the key is depressed the cable is placed in connection with the earth at E. The receiving-apparatus consists of the reflecting galvanometer, G, one terminal of which is attached to the cable, and the other to one series of plates in the condenser, C, the other series being connected with the earth, as shown in the figure. R is a very high resistance, inserted in a wire leading from the point O, between the cable and the galvanometer, so as to allow a very slight but constant leakage from the cable to the earth. The cable is therefore charged to the tension of the battery, B, and the condenser to a tension equal to that of the point, O; but owing to the resistance at R the tensions are nearly the same. Upon charging the cable with the battery at K a charge of electricity enters the cable, and a quantity sufficient to charge the condenser passes through the galvanometer, deflecting the mirror until the condenser is charged equal to the tension of the point O, when the mirror will return to zero. By putting the cable to earth at K a portion of the charge will be withdrawn, and the tension of the point O lowered below that of the condensor. A portion of the charge of the latter, therefore, flows into the cable, deflecting the galvanometer in the opposite direction. The right and left hand deflections necessary for signalling are therefore produced without reversing the currents, or rendering it necessary to entirely discharge the cable after each signal. This mode of signalling possesses many important advantages over the old method, in point of rapidity of action and freedom from interference by earth-currents.

PAPERS FOR JUNIOR STUDENTS.

The Magnetic Effects of the Electric Current.

By the passage through it of an electric current a wire becomes a magnet. In proof of this, let the student bring a wire through which a current is passing into contact with some iron filings; the filings will be attracted, and will adhere to the wire. Or let him suspend a narrow strip of gold-leaf in the field of a powerful permanent magnet, and then pass a current along the gold-leaf; it will be strongly attracted by one of the poles of the magnet (this is, in fact, MacCullagh's galvanometer). If now the wire is wound around a piece of *soft* iron, or upon a glass tube containing a bar of iron, a more intense magnetic power is developed in the bar than was evinced in the wire, and this power remains as long as the current passes. The current being interrupted, the magnetic power is also removed. Technically, the bar, glass tube, and wire constitute an *electro-magnet*, the iron being the *core*, the glass tube the *bobbin*, the wire the *coil*. In the annexed woodcut we have shown the tube, bar, and wire. When the wire is wound from

FIG. 14.



right to left, as it is there (constituting a right-handed or dextrorsal spiral or helix), and as it is in an ordinary screw, we find the north pole of the electro-magnet at the end at which the current emerges, and the south pole at the end at which it enters; the reverse being the case when the wire is wound in the opposite direction (constituting a left-handed or sinistrorsal helix), as in the following figure.

FIG. 15.

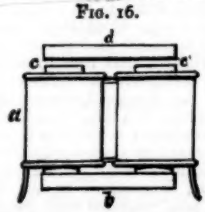
We may very easily remember the effect of the direction of the current upon the polarity by the following rule, due to Ampère:—Whatever be the nature of the helix, either right- or left-handed, if the end facing the observer has the current flowing in the direction of the hands of a watch, it is a south pole, and *vice versa*.

If we remove the iron bar, the coil itself (termed a *solenoid*) will still be magnetic, but the power will be decreased.

The wire should be *insulated*,—that is, each coil must be separated from the other by a covering of silk, or cotton, or paraffin (the latter painted on the wire while molten); for we can readily perceive that if the wire be not insulated the current would not pass through the entire series of coils, but would escape laterally.

In practice electro-magnets are generally made in a U-shape, two bobbins or spools, *a' a'* (see Fig. 16), being

FIG. 16.



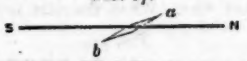
filled with covered copper-wire, and the cores, *c c'*, of soft iron fixed upon a soft iron connecting-bar. The bobbins are virtually continuations of one bobbin. The poles of the magnet are the ends of the core, *c c'*, and the piece of soft iron upon which the magnet exerts its force is termed the *armature*.

Soft iron is employed for the cores of the electro-magnet for the reason that it loses and gains its magnetism from the coil—in other words, is magnetised and demagnetised—more quickly than steel or hard iron. The opposition which a bar of iron offers to magnetisation or demagnetisation is termed its *coercive force*, and the small amount of magnetism that cannot be removed upon demagnetisation the *residual* magnetism.

It has been said that a wire becomes magnetic when

a current is passed through it; and this may be further exemplified by the following experiment, first performed by Oersted in 1819:—A copper wire is suspended horizontally, in the direction of the magnetic meridian, over a movable magnetic needle, as shown in Fig. 17.

Fig. 17.



When no current is passing in the wire the needle remains parallel to it, but immediately the ends are connected to the poles of a battery the needle is deflected, the needle approximating right angles to the wire in proportion as the current is more intense.

If we turn the wire back upon itself below the needle, so as to inclose the latter in a square or oblong frame, we increase the magnetic intensity, and this increase will be proportional to the number of turns we make. Unimportant as these facts may appear, they are the basis of the electric telegraph; and in our next number we shall proceed to study the laws of electro-magnetism, and then proceed to their application in telegraphic instruments.

Notes and Queries.

Daniell's Cells.

I have put up an electric bell, using two Daniell's cells (porous cells charged with salt and water). These cells have been in daily use for five weeks, and I find a deposit of copper upon the porous cell. How can I prevent this?—G. B. Crompton.

Armour or No Armour for Cables.

An interesting discussion has recently taken place in the columns of the *Daily News*, originating from a remark by the Rev. H. Highton, to the effect that iron destroys hemp in submarine cables as iron-mould destroys pocket-handkerchiefs. Prof. Fleeming Jenkin replies that a very extended experience has shown that in submarine cables no such action takes place. Hemp in contact with iron will last perfectly sound for twenty years at least, if covered by the iron. In some seas it is eaten by animals, but no case of this kind has been shown to have occurred in the Atlantic. Bad hemp also gradually decays when there is any wash, but iron and hemp mutually protect one another. To this Mr. Highton rejoins, that iron in contact with hemp destroys it by acting—in the form of rust or oxide—as a carrier of the oxygen dissolved in water, and so burning the hemp; and that when hemp "is covered with iron" the outside of the iron extracts the oxygen from the water, and so saves the inside where the iron is in contact with the hemp. But all this, though true of most cables, is reversed in the Atlantic cables. The hemp is not "covered with iron," but the iron with hemp,—consequently the iron rusts in actual contact with the hemp, and burns it. In some parts of the bottom of the sea there may, from various causes, be very little dissolved oxygen: where the cable is covered with fine sand or mud, the oxygen in the water immediately surrounding it is soon exhausted, and as there is little change of water to bring fresh oxygen, in such parts the decay is very slow; but in other parts, where these conditions do not prevail, where the nature of the bottom is unfavourable, or where a current brings continually fresh oxygen, the decay is very rapid. Some years ago the West India Dock Company tried hempen cables, with iron wires inside for the sake of strength, and the iron and hemp destroyed each other in even a few months. Mr. Cromwell F. Varley then takes up the subject, and says—This is so important a question that I venture to state the facts of the case. The hemp used in nearly all cables—and notably in that of the 1865 Atlantic cable—is tarred with Stockholm tar. The hemp of the 1865 cable was still further protected by a hot mixture of pitch and other ingredients, and Professor Jenkin would be strictly correct in his remarks had he inserted the words "tarred hemp." The 1865 cable is reported to be broken 500 miles from Ireland. The water at this point shoals to 1600 fathoms. It is well known—from the soundings taken by the various naval officers, both of the English Government and of the United States, who have made the deep sea soundings in the Atlantic—that the water at this depth is icy cold, and contains less salt than the upper water. It is a well-known fact to all chemists and telegraph engineers who have had actual experience in recovering cables from great depths, that where the water is cold, the iron is oxidised by it very slowly indeed, and that vegetable substances, even when unprotected by tar, scarcely undergo any decay. These two well-established facts give me reason to believe that a properly organised expedition can lift the 1865 cable west of the break, splice on a new shore end, and make it as good as before. This done, the piece between the fault and Ireland might be subsequently picked up, for the gutta-percha core is now more valuable than when first laid down. Last year I tested portions of the French Atlantic cable, of which we had many miles in store. The hemp in this cable was treated with tar and pitch, as previously described for the 1865 cable. And notwithstanding this cable had been shipped and unshipped eighteen different times, and kept in tanks filled with water of the daily surface temperature, yet the cable was found to have suffered no reduction in strength during the period of three years—in which it had been more exposed to the danger of decay than the cable laid in deep cold water. The experiments as to strength were conducted at Kirkaldy's well-known testing establishment, and the latter gentleman's report upon our experiments is in the hands of the French Atlantic Telegraph Company. None of the samples broke with less than 7¼ tons, and some bore more than 8 tons.

Post Office Telegraphs.—The official estimate for the telegraph service in the financial year 1873-74 puts the probable revenue at £1,220,000, and the working expenses and maintenance at £815,000, leaving a surplus of £405,000, out of which is to come the interest of the purchase-money. The wires used for public messages alone, exclusive of those which belong to railway companies, and are used principally for railway, and secondarily for public purposes, form a system of 100,098 miles; and the wires leased by the department to private firms or individuals for the transmission of messages on their own business between offices and factories, and so forth, make a system of 5187 miles. The total is 105,285 miles, and this mileage of wire serves 3640 postal telegraph offices and 1097 renters of private wires. There are 435 of these renters in the metropolitan division—202 in the north-western, 183 in the northern, 46 in the north-eastern, 33 in the southern, 6 in the eastern; 154 in Scotland, 38 in Ireland. The pneumatic tubes worked in London extend through a length of 12,800 yards; in provincial towns, 8069 yards—namely, 2700 in Dublin, 2405 in Liverpool, 2026 in Manchester, 698 in Birmingham, 242 in Glasgow. The estimate provides for upwards of 6000 telegraph messengers. More than half this little army is entitled to uniform clothing—tunic and cap every eight months, trousers and boots every six months, overcoat and leggings every three years. Those not entitled to uniform have, like the others, a belt and pouch every three years, and have also an arm badge.